BELLCOMM, INC.
955 L'ENFANT PLAZA NORTH, S.W. WASHINGTON, D.C. 20024

B70 10049

SUBJECT: Current Airlock Module Coolanol-15 Loop Modes of Operation - Case 620

DATE: October 22, 1970

FROM: D. G. Miller

ABSTRACT

A description is given of the Airlock Module Coolanol-15 loop and its current operational modes, from pre-launch through orbit storage. The coolant loop provides the means of transferring the Skylab internally generated waste heat to space. Coolanol-15, the working fluid of the coolant loop, has been identified as a potential flammability hazard. This memorandum describes the circuiting of Coolanol-15 for the various operational modes of the Airlock Module Thermal Control System.

(NASA-CR-111176) CURRENT AIRLOCK MODULE COOLANOL-15 LOOP MODES OF OPERATION (Bellcomm, Inc.) 9 p

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MEMORANDUM FOR FILE

I. INTRODUCTION

The Airlock Module (AM) coolant loop provides active thermal control for the Skylab. Coolanol-15, the working fluid of the coolant loop, has been identified as a potential flammability hazard. Possibilities for eliminating this potential hazard are discussed in Reference 1.

The purpose of this memorandum is to provide background on the use of Coolanol-15 in the current AM system by describing the circuiting of the Coolanol-15 and the operational modes of the system during various mission phases.

The AM coolant system consists of two separate, parallel (primary and secondary) loops provided for redundancy. These loops individually or together remove waste heat from the EVA/IVA suit cooling module, condensing heat exchangers, cabin heat exchangers, tape recorders, cold plates, oxygen heat exchanger, control and display (C&D) panel heat exchanger, pump module, battery modules and electronic modules. The waste heat is rejected to space by radiators and a thermal capacitor located on the outside of the Multiple Docking Adapter (MDA) and the Structural Transition Section (STS) of the AM.

The Coolanol-15 loop has the flexibility to provide cooling throughout the mission from pre-launch through orbit storage. The various phases of the mission are broken down as:

1. Pre-launch
2. Launch
3. Predocking
4. Crew Entry
5. Normal Orbit Operation
6. Storage

The coolant loop operation is described for these mission phases in many documents listed in the bibliography. The information in these documents was reviewed and appears to be consistent. The majority of the information concerning phases 1 through 4 was found in the "Systems Operating Procedures, Volume II".[15] The normal orbital operation (phase 5) was determined from data presented in references 8 and 16. No single reference was found which specifically described the storage phase; items which require cooling during storage are tabulated in reference 9.

II. COOLANOL-15 LOOP DESCRIPTION

Figure 1 shows the current coolant system. The radiator is shown as a bifilar circuit (each coolant loop split into two parallel passes) with manual selector on-off valves controlling the primary and secondary loops. At the outlet of the radiator the Coolanol-15 enters the thermal capacitor, which is charged with tridecane wax. The capacitor stores heat on the sun side of the orbit and rejects heat on the dark side using the wax thermal capacity and liquid-solid phase change. Heat is transfered between the coolant and the wax to provide a moderated cold temperature for the coolant circuit.

Downstream of the capacitor the coolant enters the EVA/IVA suit cooling module. Here the coolant temperature is controlled by a temperature control valve (TCV) which is manually set for 40°F at both normal operation and for EVA/IVA. The TCV apportions the coolant just upstream of the radiator. The heat exchange in the suit loop is between the Coolanol-15 and the water in the suit cooling module. As shown in Figure 1, the coolant first enters a three pass counterflow heat exchanger (2 pass coolant to 1 pass water) and connects in series to a two pass counterflow heat exchanger (1 pass coolant, 1 pass water). This unique arrangement of heat exchangers relative to the TCV prevents water freezing problems.

From the suit cooling module the Coolanol-15 goes to the condensing heat exchangers. Each molecular sieve has two condensing heat exchangers, controlled by manually operated coolant valves and air compressors. The condensing heat exchangers provide for water removal control in the vehicle by means of heat exchange between the cabin air/water vapor and the coolant.

Cooling of the Skylab workshop (WS) is provided by the four cabin heat exchangers shown just downstream of the condensing heat exchangers. Heat transfer in this case is from the cabin air (fan powered) to the coolant. There is no individual control of coolant flow, i.e. whatever leaves the condensing heat exchangers passes through the aft heat exchangers in parallel. Aft heat exchanger operation is controlled by a thermal controller located in the WS which senses atmosphere temperature. Each aft heat exchanger has a fan and an air valve, which are selected by the WS thermal controller logic.

From the aft cabin heat exchangers, the coolant flows to the three STS heat exchangers, two of which are controlled by manual on-off valves. The STS heat exchangers provide atmosphere cooling for the AM/MDA by means of heat transfer from the cabin air (fan powered) to the coolant.

Downstream of the STS heat exchangers the tape recorders are cold plated to the coolant line and downstream of the tape recorders is the C&D panel heat exchanger. Water from the C&D panel loop is cooled by the AM coolant loop at the ATM water pump module shown in Figure 1. Also within this module, oxygen for EVA or initial pressurization of the cluster is temperature-controlled by heat exchange with Coolanol-15 at the O_2 heat exchanger.

After the ATM water pump module are the battery cold plates, controlled by eight metering valves, cold plated electronics, and finally the coolant reservoir module containing eight Gemini-type Coolanol-15 reservoirs.

From the reservoirs, the flow enters the coolant pump module. Each loop has a pump package containing three coolant pump/motor units. The pump motors are powered with separate power supplies. The pumps are activated by a manual switch; one pump in the primary loop can be turned on by DCS command. From the pumps the flow enters a selector valve which allows the flow either to pass to the radiator or to bypass to a ground cooling heat exchanger.

III. COOLANOL-15 LOOP MODES OF OPERATION

Coolanol-15 loop operation is described below according to the various mission phases.

1. Prelaunch[15]

For prelaunch operation one pump is turned on to provide flow only in the primary circuit. The flow is controlled by the selector valve to bypass the radiator circuit. Waste heat from the AM equipment operated during prelaunch is rejected by a ground cooling heat exchanger shown in Figure 1. Heat transfer in this mode of operation is between the coolant and the water in the ground cooling heat exchanger.

2. <u>Launch</u>[15]

At umbilical separation, the coolant pump in the primary loop is off and the radiator flow for the primary loop is set normal. Normal setting allows flow through the loop and radiator, but the pump is off and there is no coolant flow.

3. <u>Predocking</u>[15]

At T + 10 minutes one coolant pump in the primary loop is turned on by DCS command. Primary coolant loop flow is used to provide cooling for AM electronics prior to crew entry.

4. <u>Crew Entry</u>[15]

The radiator flow in the primary and secondary loops is set normal. Two primary pumps are on; the third primary pump and all secondary pumps are off. Two STS heat exchanger valves are set open and, since there is no valve on the third heat exchanger, all three STS heat exchangers have coolant flow and can be activated by turning on the fans.

5. <u>Normal Orbit Operation</u>

The normal orbit operation is described in terms of the extremes of coolant loop operation for maximum waste heat removal (Hot Case) and minimum waste heat removal (Cold Case), and for intermediate cases. Additionally, the EVA/IVA coolant loop operation is described.

<u>Hot Case for the Workshop</u>

Two coolant loops are operated with one pump on in each loop. Two pumps may be turned on in each loop during portions of the mission.[16] Constraints on duration for two pumps per loop operation have not been identified.

Two condensing heat exchangers, three STS heat exchangers and four aft heat exchangers are operating.

<u>Hot Case for the AM/MDA</u>[8]

Two coolant loops are operating with one pump on in each loop. Two condensing heat exchangers and three STS heat exchangers are on. Coolant flows through the four aft heat exchangers, but the fans controlling the air through the heat exchangers are turned off and the air valves are closed, which essentially eliminates heat transfer.

Cold Case[8]

One coolant loop is on, powered by one pump. Coolant flow is shut off in two STS heat exchangers, and the remaining STS heat exchanger bypasses flow of the coolant circuit. Two STS fans are on for gas circulation. Coolant flows through the four aft heat exchangers, but the fans are off and the air valves are closed. One condensing heat exchanger is on.

AM EVA/IVA[8]

Two coolant loops are operating with one pump per loop. One condensing heat exchanger is on and three STS heat exchangers are operating. The four aft heat exchangers carry full coolant flow, but the fans are off and the air valves are closed.

6. Storage

During storage, cooling must be provided for the pump module and AM electronics, which include the battery module and tape recorders.[9] One coolant loop powered by one pump meets this storage requirement.

IV. COOLANOL-15 LOOP CONTINGENCY

The coolant loop is provided with component redundancy and can be operated in modes other than the ones described. There are four condensing heat exchangers which are controlled by eight manual on-off valves. Six coolant pumps can be manually switched into the coolant loops on separate power supplies. Contingency operation occurs during component failure or special emergency situations. It is beyond the scope of this memorandum to discuss contingency operation; detailed information on the AM coolant loop failure modes and contingency operation can be found in Reference 17.

D. G. Miller

1022-DGM-tla D. G. Miller

Attachments
Bibliography
Figure 1

BIBLIOGRAPHY

Listed below are sources of material and references used to describe the AM coolant loop modes of operation.

1. Miller, D. G., "Coolanol-15" - Case 620, Bellcomm Memorandum B70 10048, October 21, 1970.

2. "OWS Solar Array Trade Study Considering Capability to Provide Cooling for OWS Atmosphere", Report G434 Final Report MDAC-ED, July 1969.

3. "Cluster Systems Document", MSFC Report MAN-001-AP, May 1969.

4. "Airlock Design Data Book", MDAC-ED Report, November 1969.

5. "Preliminary AAP Mission Constraints", FCOB, FCD Report, March 1969.

6. "Saturn 5 Workshop Program Definition Study", MSFC Report, June 1969.

7. "Apollo Applications Program Specification", SE140-001-1, August 1969.

8. "Airlock ECS and TCS", Handout from CSDR, December 1969.

9. "Airlock Data Package ECS and TCS", Handout from CSDR, December 1969.

10. "AAP Cluster System Review ECS and TCS Presentation", Handout from CSDR, December 1969.

11. "OW Cluster Systems Review Data Package ECS/TCS", Handout from CSDR, December 1969.

12. Airlock Performance/Configuration Specification Flight Articles No.-1 and No.-2, MDAC-ED, September 1969.

13. "AM/MDA TCS Interface Document", MDAC-ED Report F706, March 1968.

14. "AM/S-IVB ECS Interface Document", MDAC-ED Report F712, May 1969.

15. "Systems Operating Proceedures Volume II", MSC Report NAS9-6555, MSC-IS EX. B, February 1970.

16. "Minutes of the Apollo Applications ECS/Thermal Subpanel Meeting No.-12", March 1970.

17. "Airlock Module Failure Mode and Effects Analysis", MACDAC No. 1003, March 1970.

18. "Airlock Preliminary Design Review", MDAC-ED Report, November 29, 1967.

COOLANT SYSTEM

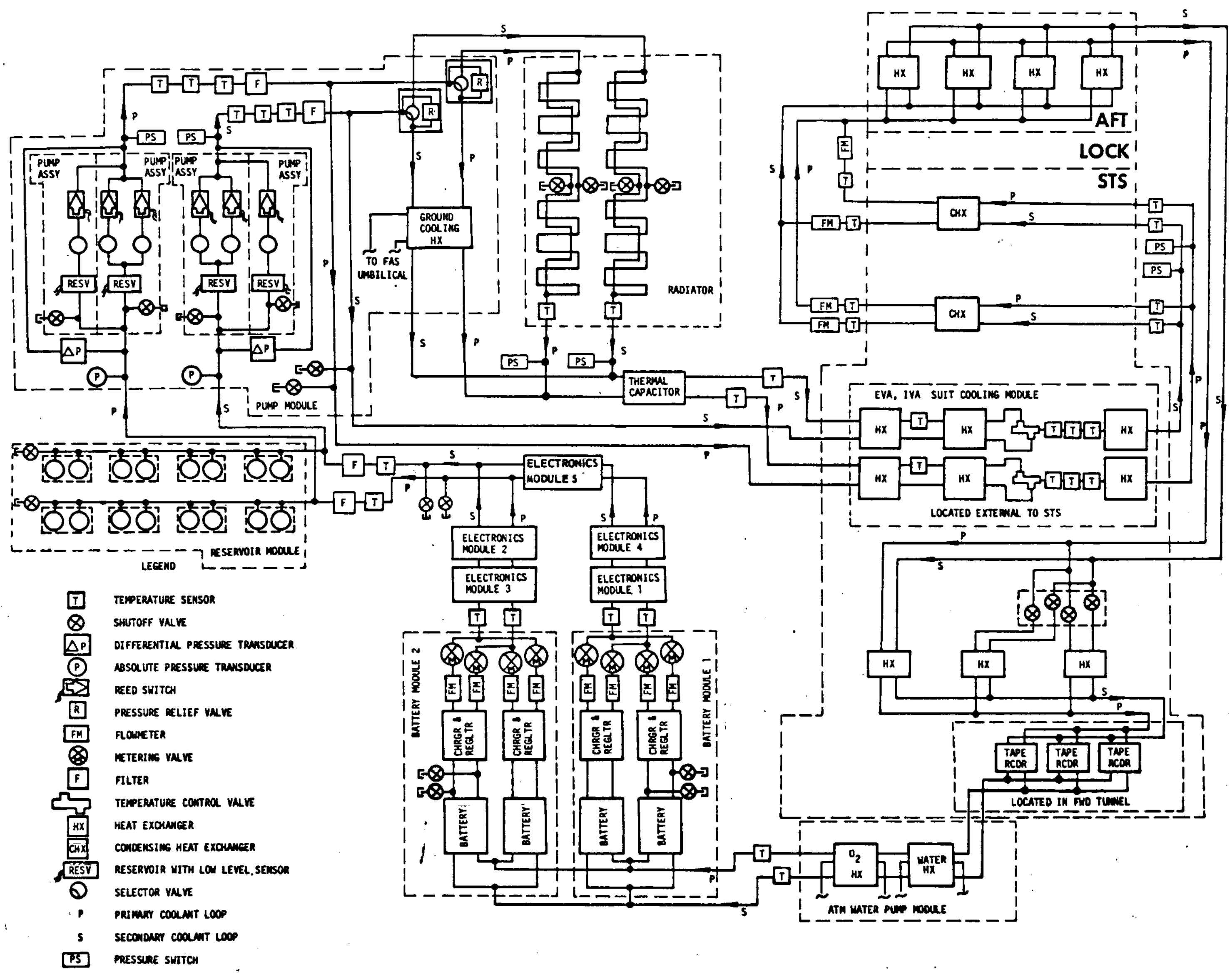

Figure 1

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